Micronutrients and the use of vitamin and mineral supplements during pregnancy and lactation

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A pregnant women's dietary can have profound effects on pregnancy outcomes and adult disease risk in offspring. This is particularly so of some vulnerable groups of pregnant women including adolescents, vegetarians and vegan, underweight women, obese women and women who have undergone bariatric surgery. These groups present nutritional challenges and require additional supervision during pregnancy. This paper discusses the effects of dietary supplements in relation to the specific needs of the aforementioned groups in comparison to the needs of the general pregnant population.

Introduction

Optimal birth weight is often seen as the primary indicator of a positive pregnancy outcome and a low birth weight or a baby born small for gestational age is indicative of impaired foetal development (Gluckman et al. 2005). However, cardiovascular disease (CVD), obesity, type 2 diabetes mellitus (T2DM) and depression associated with birth weights within the range for normal birth weight have also been observed (Jackson and Robinson 2001). This suggests that nutritional factors play an important role in foetal development and pregnancy outcomes. Pregnancy is a time when the maternal diet is essential not only for the health and well being of the mother but also for the healthy development of the growing foetus. There has been more focus on maternal diet in the last few years, highlighting the consequences of sub-optimal nutrition in terms of pregnancy outcomes and long-term risks to offspring. There is a growing body of evidence linking maternal diet with an increased risk for adult onset metabolic diseases such as T2DM, CVD and some cancers (Poston 2011; Blumfeld et al. 2012; Rao et al. 2012; Wood-Bradley et al. 2013). Furthermore, research by Nyaradi et al. (2013) has highlighted that micronutrients such as vitamin B_{12}, folate, zinc and iodine play a role in the neurocognitive development of babies and children.

The majority of people in developed nations, including the UK, receive an adequate supply of micronutrients if they consume a normal balanced diet which meets their normal energy requirements and contains all the main food groups such as fruit & vegetables; milk & dairy; bread & cereals and meat and non-meat alternatives;. However, there are some vulnerable populations where these requirements may not be met and pregnancy increases this risk (Berti et al. 2011).

Micronutrients

Micronutrients are defined as vitamins, minerals and trace elements. They are required in tiny amounts, for various essential functions, in either milligrams or micrograms per day but have no calorific value (Bender 1995). The required amounts are variable at population level but for the avoidance of deficiencies, dietary reference values (DRV's) have been established for most of the micronutrients for pregnancy and lactation. Dietary reference values are a guide to the amount of nutrients that are sufficient or more than sufficient for the majority of the population. For vitamins and minerals DRV's are defined as the reference nutrient intake (RNI) or lower reference nutrient intake (LRNI) and represent the upper and lower values of normal range for population requirements. The amounts recommended assume a normal population distribution and may be insufficient for some pregnant populations, pregnant women with obesity and some ethnic minorities for example. Table 1 illustrates those micronutrients that have an additional requirement during pregnancy and/or lactation.

Table 1: Characteristics of micronutrients (Bender 2002, Strain and Cashman 2002)

Nutrient/ DRV's for females 19-50yrs (COMA 1991)	**Principle functions**	**DRV's for pregnancy/ lactation**	**Dietary sources**	**Deficiencies & symptoms**
Vitamin A Retinol β-carotene **600µg/d**	Visual pigments in retina, cell differentiation, antioxident	700/900µg/d	Liver, fish liver oils, vegetables (carrots), fats. milk and cheese	Night blindness Keratinization of skin
Vitamin B_1 Thiamin **0.8mg/d**	Coenzyme in metabolism of CHO, fat & alcohol	0.8-0.9*/1mg/d	Cereals, cereal grain, beans, seeds, nuts, fortified foods	Beri Beri (peripheral nerve damage), Wernicke-Korsakoff syndrome (CNS lesions)
Vitamin B_2 Riboflavin **1.1mg/d**	Coenzyme in oxidation and reduction reactions	1.4/1.6mg/d	Milk & dairy products, meat (liver), eggs, green leafy vegetables if eaten in large amounts	Lesions to corner of mouth, lips, tongue. Sebhorreic dermatitis
Vitamin B_6 **Pyridoxine** **1.2mg/d**	Coenzyme in metabolism of amino acids	1.2**/1.2**mg/d	Nuts, meat, fish, wholegrain cereals and beans	Very rare but in extreme cases can cause disorders of amino acid metabolism & convulsions
Vitamin B_{12} **Cobalamin** **1.5µg/d**	Coenzyme in metabolism of folic acid and cell division	1.5**/2.0 µg/d	Meat, eggs & dairy products	Pernicious anaemia
Folate * 200µg/d**	Coenzyme in single carbon transfer reactions	300/260µg/d	Green leafy vegetables, yeast, liver, fortified cereals	Megaloblastic anaemia, Implicated in NTD's during pregnancy

Vitamin C Ascorbic acid **40mg/d**	Cofactor for oxidase enzyme reactions, antioxidant, assists in absorption of non-haem iron, wound healing	40-50*/70mg/d	Fruit & vegetables (inc potatoes)	Scurvy, impaired wound healing, loss of dental cement, subcutaneous haemorrhage
Vitamin D Calciferol **N/A**	Maintenance of calcium balance, enhances intestinal absorption of Ca^{2+}, mobilises bone mineral	10/10µg/d	Fats & oils, meat & meat products, fish, fortified foods, milk	Rickets (impaired bone mineralisation) Osteomalacia (demineralisation of bone)
Calcium **700mg/d**	Bone & teeth formation and maintenance Nerve impulse transmission, muscle contraction, blood clotting	700**/1250 mg/d	Dairy, fish, meat, bread, spinach, watercress, broccoli, peas, tofu	Osteoporosis (reduced bone mass) Hypertension (inc pre-eclampsia), colon cancer
Iron **14.8mg/d**	Forms part of haemoglobin molecule that transports oxygen from lungs to tissues, component of various enzymes that regulate immune system functioning and energy production	14.8**/14.8** mg/d	Haem iron from meat (liver) & fish Non-haem iron from legumes, green vegetables, nuts, dried fruits	Iron deficiency anaemia → fatigue, restlessness, impaired cognitive performance, thermoregulation, immune response.
Iodine **140µg/d**	Constituent of thyroid hormones thyroxine (T_4) & triidothyronine (T_3) that modify development & growth, stimulate enzyme synthesis, oxygen consumption & basal metabolic rate	140**/140** µg/d	Milk, seafoods, iodized salt	Goitre (enlarged thyroid gland) Congenital mental and growth retardation. Pregnancy → cretinism in offspring
Magnesium **270mg/d**	Acts as a co-factor for enzymes requiring ATP Maintains electrical potential in nerve and muscle membranes	270**/320mg/d	Green leafy vegetables, cereals. Meat and animal products rich sources but simultaneous intakes of calcium & protein reduce bioavailability	Deficiencies very rare and only seen as a secondary complication of a primary disease state or as a result of rare genetic abnormalities of magnesium homeostasis
Phosphorous **550mg/d**	Component of nucleotides, nucleic acid and ATP; occurs as phospholipids, a major components of cellular membranes. Supports tissue	550**/990mg/d	Ubiquitously found in all natural foods but rich sources include dairy products, meat, fish, eggs, tofu, vegetables	Deficiency only evident as a result of near total starvation

	growth through pregnancy and lactation			
Selenium **60µg/d**	Integral component of glutathione peroxidases, potent intracellular antioxidant enzymes	60**/75µg/d	Fish, shellfish, red kidney beans, Brazil nuts, lentils, liver, pork	Keshan disease associated with selenium depleted soil in areas of China Sub-optimal selenium status may predispose to other deleterious conditions but can be ameliorated by vitamin E
Zinc **7.0mg/d**	Constituent of many regulatory & catalytic enzymes responsible for signal transduction & gene expression, structural role as zinc finger motifs in proteins, DNA & RNA	7**/13mg/d	Lean meat (offal),seafoods, dairy, pulses, wholegrains,	Growth retardation In pregnancy, preterm delivery, low birth weight

* Last trimester only ** No increment

*** Recommendation for all women to take 400µg folic acid supplement pre-conceptually until 12 weeks gestation (women with previous NTD, RCOG recommended to take 5mg folic acid).

The majority of micronutrients can be derived from a variety of fresh, frozen and canned fruit and vegetables, wholegrains, legumes, beans and pulses, lean meats and up to 2 portions of oily fish per week (during pregnancy) (Williamson 2006). There are additional benefits to consuming fruit and vegetables. Most plant foods have a complex matrix containing many bioactive compounds, known as phytochemicals, in addition to multiple vitamins and minerals and there is growing evidence to suggest that there is an additive and synergistic relationship between phytochemicals and micronutrients enabling optimum bioavailability, absorption and utilisation (Liu 2013). Additionally, evidence suggests that many phytochemicals found in fruit, vegetables and whole grains have antioxidant, anti-inflammatory, anti-obesity and chemo-preventative properties (Williams et al. 2013).

There are also a number of fortified foods available including bread, breakfast cereals, spreads and beverages (Yang 2011). Fortified foods are one of the strategies used for modifying the diet at population level, the others being nutritional education and dietary supplements. However, there needs to be careful consideration given to dietary changes ensuring the requirements of specific populations with regard to suboptimal or excessive intakes. There is increasing availability of over the counter dietary supplements and (voluntarily) fortified foods. This has resulted in significant differences in micronutrient intakes within populations (Verkaik-Kloosterman et al 2012). Consequently, safe upper limits have been set for a number of nutrients. The upper limit is defined as the highest level of a nutrient that can be consumed that is likely to pose no risk for adverse effects in the general population. Consumption of a nutrient, above the safe upper limits, is likely to increase the risks of adverse effects, particularly in respect of damage to the developing foetus (Stanner 2000). This is an unlikely event for most nutrients if consumed as part of a normal balanced diet, however, concomitant intakes of fortified foods and dietary supplements may lead to excessive intakes. Additionally, many dietary supplements have ‘overage’ of nutrients and nutrient content can deviate by as much as 25-50% from that stated on the label (Yetley 2007). Overage ensures that the levels of the nutrient at the end of shelf life reflect the amounts indicated on the product label, consequently, there may be significantly more than what is stated at the start of its shelf life (EVN 2003). Therefore, supplement use within the pregnant population needs to be determined as early on as possible and inappropriate usage deterred.

Groups at risk of deficiencies

There is risk of deficiencies of certain nutrients in some populations. Obese women, defined as having a BMI ≥30kg/m^2, underweight women, defined as having a BMI ≤18.5kg/m^2, adolescent girls, some ethnic minorities, vegetarians and vegans are at risk of impaired nutrient status particularly during pregnancy and breastfeeding.

Teenage pregnancy

Adolescent females are particularly vulnerable during pregnancy as they are undergoing periods of growth and development, where there is a higher than usual requirement for nutrients. They are at much greater risk of delivering low birth weight (LBW) or small for gestational age (SGA) infants as a result of preferential nutritional partitioning (Jones et al. 2009). Data from the National Diet and Nutrition Survey (NDNS) suggest that teenage girls are below the lower reference nutrient intake (LRNI) for a number of nutrients including calcium, iron and folate. The LRNI is the amount of a nutrient that may be sufficient for a small minority in the population with lower than normal requirements but not enough for the majority. Moreover, there is likely to be competition for nutrients between the mother and foetus during an unplanned pregnancy (Williamson 2006). The risk for anaemia and poor maternal nutrition is much greater in this group and as such, increased neonatal mortality and morbidity, with intra-uterine growth restriction (IUGR), small for gestational age (SGA) and pre-term deliveries are more likely (Treffers et al. 2001). Furthermore, pregnant teenagers are less likely to access maternity care in early pregnancy and are more likely to miss appointments, therefore, missing out on essential early antenatal care and nutritional advice (DH 2008). Despite, the increased risks, pregnant teenagers do not receive additional nutritional support and advice is similar to that meted out to all pregnant women with a recommendation for Healthy Start vitamins. Pregnant teenagers often have poor nutritional knowledge and inadequate dietary intakes, therefore, health professionals are in a position to educate them of the importance of a healthy balance diet during pregnancy or if required, signpost them to a registered nutritionist/dietitian (Derbyshire 2007). Montgomery (2003) suggests that making it as easy as possible for them by focussing on foods rather than nutrients and rewarding effort may help them to optimise their nutrition.

Ethnic minorities

Women of certain ethnic origin living in Northern Europe and the UK are at risk of Vitamin D deficiency. This is likely due to cultural dress codes limiting exposure to sunlight, darker skin pigmentation and a lack of vitamin D rich foods in the diet (Judd 2013). Women of ethnic minorities are more likely to be vegetarian and/or have dietary restrictions because of religious practices. This has resulted in a resurgence of rickets in offspring, compounded by extended duration of breastfeeding and a lack of exposure to sunlight. This could be due to health related messages regarding sun exposure and cancer. Rickets may also result because of calcium deficiency; as such, calcium status needs to be assessed in addition to plasma 25 hydroxy vitamin D, which is the concentration measured to determine vitamin D status (Allgrove and Mughal 2014). Women who have travelled from poorer nations or under-developed countries may be deficient in other nutrients, such as iron, zinc, vitamins A, B_6, B_{12}, C, E and riboflavin as a consequence of inadequate meat, and fruit and vegetable intakes (Zerfu et al. 2013). Iron deficiency anaemia is the most prolific nutrient deficiency in the world and has implications for low birth weight and pre-term delivery. Supplementation of iron during pregnancy may be insufficient to restore iron stores and correct the effects of anaemia (Scholl 2011).

Vegetarians and vegans

Vegetarians and vegans offer nutritional challenges during pregnancy as nutritional intakes can vary in vegetarians and vegans as much as the general population (Tyree 2012)., Nutrient intakes of calcium, vitamin B_{12}, riboflavin and iodine in vegetarian and vegan populations, have been shown to be below RNI, particularly in vegans. Intakes for iron and zinc may also be vulnerable because of the exclusion of meat and fish from the diet. However, the majority of these requirements can be met with careful dietary planning and the inclusion of some fortified foods (Williamson 2006) and this is more likely to be achieved with the support and/or supervision of a registered dietitian/nutritionist. Physiological adaptations during pregnancy enable increased iron absorption as the need for iron increases throughout gestation. However, dietary intake alone is insufficient to ensure optimum utility and is therefore dependent on existing pre-pregnancy iron stores (Hallberg 2001). As such, in the vegetarian and vegan population, pre-natal iron supplementation maybe necessary to ensure sufficient iron stores to adequately sustain pregnancy and lactation.

Obesity

The risks for adverse pregnancy outcomes are significantly increased in the obese population. Maternal risks include gestational diabetes mellitus (GDM); hypertensive disorders including pre-eclampsia. Foetal risks include macrosomia, neural tube defects (NTD), IUGR and genetic malformations (Cnattingus et al. 1998, Sebire et al. 2001). Inadequate dietary folate intake in the pre-conceptual period is associated with an increased risk for NTD's (Laurence 1983, cited in McMahon et al. (2013) and evidence from randomised controlled trials (RCT) shows an inverse dose-response relationship between folate status and NTD's (SACN, 2006). Therefore, all women are recommended to take a 400ug/d folic acid supplement pre-conceptually until at least 12 weeks gestation (NICE 2008a). However, women with a BMI ≥30kg/m^2 and women who are at increased risk of having a baby born with a NTD are recommended to take 5mg/d folic acid supplement (RCOG2014). This includes women who have previously had a baby born with a NTD, women with diabetes and women with a genetic variant of specific genes that code for enzymes associated with folate metabolism (SACN 2006).

Inadequate maternal nutrition is implicated in adverse pregnancy outcomes. Pregnant women with obesity are at increased risk for micronutrient deficiencies, this is often due to poor eating behaviours and a reliance on energy dense/ nutrient poor foods (Moran et al. 2013). Nutritional data gathered as part of the 'Fit for Birth' study at Liverpool Women's Hospital of pregnant women with a BMI ≥35kg/m^2, demonstrated that although total energy intakes were only slightly below estimated average requirements (EAR) for energy, many of the women were below RNI for a range of micronutrients including iron, vitamin D, folate, iodine and calcium. Furthermore, when micronutrients were measured as a ratio of total energy, it was found that intakes declined between 16 weeks and 36 weeks gestation. These findings suggest a dilution of micronutrients, which are compounded even further when levels of underreporting are taken into consideration (Charnley 2015). Pregnant obese women are in need of much greater nutritional support and a multidisciplinary antenatal approach is advocated with direct referrals to dietetic services in line with NICE guidelines. A number of recent lifestyle intervention trials are nearing completion in which a multidisciplinary approach is being taken. All these studies have looked at behaviours in terms of dietary intake, physical activity levels and lifestyle. The UPBEAT trial, (Poston et al) The Lifestyles course (Lavender et al) and HELP trial (Simpson et al) are all aimed at improving pregnancy outcomes in the obese pregnant population using behavioural change techniques.

Underweight

Underweight or low BMI (≤18.5kg/m^2) is associated with impaired fertility (Williamson 2006) and underweight women who do conceive have a 72% increased risk of miscarrying in the first trimester compared to normal weight women (Bainbridge 2007). Maternal underweight is also known to impact on neonatal morbidity. A growing number of studies have shown that maternal underweight significantly increases the risk of LBW, SGA and preterm deliveries (Han et al. 2011, Jeric et al. 2013, Salihu et al. 2009). Low birth weight and IUGR have been identified as predictors for long term adult health risks such as coronary heart disease (CHD) and T2DM as a result of sub-optimal nutrition *in utero* and foetal programming (Barker et al. 2010, Gluckman et al. 2005, Osmond and Barker 2000). There is also evidence to suggest an association with pre-pregnancy maternal underweight and neurocognitive development in offspring. A study by Polanska et al. (2015) showed decreased language skills at 12 months and cognitive and motor development at 24 months in the offspring of women with a BMI ≤ 18.5kg/m^2.

Socio-economic status

Obesity and underweight are both associated with low socio-economic status (SES) (Doak et al. 2004) and it is not uncommon to find both ends of the spectrum co-existing in some deprived wards. This was highlighted in a study in Liverpool by Abayomi et al. (2009) in which women's height, weight and BMI data along with postcodes were mapped using geographical information system (GIS) and 'hotspots' identified. A study by Fowles (2002) looked at differences between low income and middle income women in the USA in terms of nutritional knowledge, dietary intakes and weight gain during pregnancy. The study showed that weight gain in women with a low pre-pregnancy BMI was lower than that of women who had a high pre-pregnancy BMI, who tended to gain more weight than that recommended by Institute of Medicine (IOM). Additionally, the study found that nutritional requirements for pregnancy had not been achieved.in either of the groups even though energy from carbohydrate and protein intakes and percentage of energy from fat exceeded recommendations, as did that of sodium. Their dietary records showed an increased consumption of bread, fried or processed meat products such as fried chicken and hotdogs in the low income group. Positive dietary changes prior to and during pregnancy would help to improve both maternal wellbeing and neonatal outcomes.

Pregnancy following bariatric surgery

Another subset of pregnant women that require attention is women who have undergone bariatric surgery prior to them becoming pregnant. This is a relatively new procedure and the possible repercussions of bariatric surgery on long-term offspring health are yet to be observed. Bariatric surgeons advise women to leave a minimum of 18 months following surgery before attempting to conceive to allow for weight stabilisation thus decreasing the risk of maternal and foetal malnutrition resulting in SGA (Edwards 2005). However, a study by Devlieger et al (2014) looking at the nutrient status of 49 pregnant (18 following restrictive surgery and 31 following malabsorptive surgery) found that most nutrients were depleted at 12 weeks gestation and declined significantly throughout pregnancy, despite self-reported intakes of supplements during trimester 1 and additional supplement intake during trimesters 2 and 3. An earlier study by Pilezzo at al (2013) highlighted 3 clinical cases of foetal neural defects and malnutrition during pregnancy in women following bariatric surgery. None of the 3 women took nutritional supplements following the surgery or took advantage of nutritional surveillance or counselling. Only one of the women was taking supplements prior to conception but stopped within 6 weeks gestation. The other 2 women only started nutritional supplements between 20-22 weeks gestation but all 3 were deficient in many nutrients including vitamin A, vitamin B_{12}, and the active form of vitamin D. Women who have undergone bariatric surgery are reliant on dietary supplements to sustain optimal health and there is the possibility of a conflict between maternal and foetal health status, however both these studies suggest that compliance with nutritional supplement regimens is poor in many women following bariatric surgery despite becoming pregnant (Devlieger et al 2013, Pilezzo et al 2013). It is likely that some general recommendations may not be appropriate to this group, particularly with regard to the avoidance of vitamin A and recommended intakes of 400μg/d folic acid. Furthermore, there are nutritional concerns regarding the quality of breast milk in post bariatric women who have undergone malabsorptive surgery. Inadequate serum vitamin B_{12} levels observed in some lactating women may result in neonate deficiency and fat malabsorption may reduce the energy available in the breast milk, potentially affecting infant growth (Harris and Barger 2010). This suggests that careful pre-conceptual nutritional planning and increased post-partum nutritional monitoring may also be required in this population.

Nutritional support

All pregnant women require nutritional support throughout pregnancy, to ensure optimal pregnancy outcomes. However, the vulnerable population groups described here present major challenges to dietitians and nutritionists. Nutritional assessment is necessary to determine the adequacy of dietary intakes and establish personalised requirements.

Supplementation

NICE guidelines (2010) state that women who present for maternity services or health visitor appointments should receive healthy eating advice and those with a BMI ≥30kg/m^2 should be offered a structured weight loss programme following childbirth (NICE 2010). All pregnant women are advised to take 400μg folic acid <u>and</u> to eat foods that provide a rich source of folate or folic acid. For women who have a family history of NTD's, have had a baby with a NTD or if the woman has pre-existing diabetes then 5mg/d is prescribed. Evidence suggests that it is folic acid taken 12 weeks prior to conception and 28 days post conception that is most effective in reducing the risk for NTD's and that folic acid supplements taken in the later stages of pregnancy confer no additional benefit (Lassi et al. 2013). Vitamin D status in breast fed infants is entirely dependent on the vitamin D status of the mother, therefore, a vitamin D supplement of 10μg/d is now recommended for all pregnant and breastfeeding women (NICE 2008).

NICE guidelines recommend the use of specific supplements such as folic acid, vitamin C and vitamin D. Additionally; iron supplements are also prescribed by GP's in some cases if haemoglobin levels are below 110g/L during the first trimester or 105g/L at week 28 of pregnancy, which are considered outside the normal range in the UK (SACN 2010). Healthy Start vitamins for pregnant women; currently contain - 70mg vitamin C, 10μg vitamin D and 400μg folic acid. However, opinion suggests that the 10μg/d of vitamin D recommended may be insufficient for many high risk groups and that trials to identify vitamin D intakes that would optimise circulating levels of 25(OH)D_3 are needed (SACN 2007). Women in receipt of benefits who are signed up to the Healthy Start scheme receive the vitamins for free and these are widely available via antenatal clinics and children's centres (NICE 2008). Some local authorities including Liverpool make the supplement available to all pregnant women but they are not free in all authorities (NICE 2008b).

It is generally acknowledged that additional micronutrient supplementation may support pregnancy owing to the demands that pregnancy places upon the body. However, the mechanisms as to how micronutrient supplementation affects pregnancy outcomes are not fully understood (Bekker, 2009). It is postulated that improved immune function may reduce the risk of infection thereby preventing preterm delivery; they may also improve energy metabolism and anabolic processes leading to a decrease in IUGR prevalence as well as improving the maternal response to stress (Shah and Ohlsson 2009). However, there is insufficient evidence attributing a deficiency of a specific nutrient to an adverse pregnancy outcome (Keen et al. 2003).

The use of supplements in certain populations has proven to be effective in mitigating the risks of low birth weight babies, of which there is a higher prevalence in the UK compared to other EU and developed countries (Ashdown-Lambert 2005), small for gestational age babies, and pre-term deliveries. This is particularly apparent in poorer countries.

Limitations of dietary supplements

With the exception of folic acid, for the prevention of NTDs and vitamin D supplementation, there is still insufficient evidence of any conferred benefit to pregnant women in developed countries from nutritional supplements (Picciano 2003). These findings are also supported by a review of interventions including 23 trials involving over 76,000 women assessed the effectiveness of multiple micronutrient supplements (MMS) in comparison to single micronutrient supplements. The findings suggested a positive effect on reducing SGA and low birth weight babies but no statistically significant differences for any other pregnancy outcome including pre-term births, miscarriage or maternal and neonatal mortality (Haider and Bhutta 2012).

Women need to be assessed with regard to supplement use and in developed countries such as the UK more consideration needs to be given to maternal diet. This should be reviewed as part of antenatal care to ensure that there is no risk of nutrient-nutrient interactions, which may affect the bioavailability, absorbency and/or utilisation of a nutrient, for example iron inhibits the absorption of zinc and calcium impairs the absorption of iron (EVN 2003). Additionally, nutrient-pharmaceutical interactions, which may either impair drug efficacy or inhibit nutrient absorption as a result of supplementation (Yetley 2007). Additionally, there is insufficient information about what constitutes the optimal micronutrient supplement during pregnancy, regarding what nutrients should be included, what form and when they should be taken (Keen et al. 2003).

The consensus is that all women of reproductive age in developed nations should be made aware of the importance of a nutrient rich dietary intake during pregnancy to ensure optimal pregnancy outcomes (Williamson and Wyness 2013).

Conclusion

The use of MMS needs to be approached with due caution. Whilst the use of supplements may be able to mitigate adverse outcomes in certain populations, there is still a question over optimal recommendations and in some cases it has been shown that over consumption may increase adverse outcomes. Animal model studies have also alluded to the possibility that higher micronutrient intakes during pregnancy may also be implicated in the risk for adult disease in offspring when exposed to an obesogenic diet post weaning (Lopez et al. 2013). Furthermore, because of the transgenerational impact of inadequate nutrition, it is sensible to encourage pregnant and breastfeeding women to consume nutrient rich foods to encourage positive weaning and early child feeding practices. It is more important that pregnant women are educated with regards to optimal nutrition and they derive their required nutrients from dietary sources where possible. Moreover, it could be argued that if supplements are going to have any effect, they should be taken pre-conceptually, as most complications of pregnancy arise in the first few weeks following conception.

The take home message has to be that pregnant women are 'eating for two' not in terms of quantity but, crucially, in terms of quality. It is the emphasis on eating a healthy balanced diet during pregnancy and breastfeeding that will potentially provide optimal maternal health, reverse the obesity trend and reduce the risk of metabolic diseases in the adult offspring. Moreover, there cannot be one-size fits all approach to nutrition and supplementation during pregnancy. Individuals have many differing needs that often go beyond the remit of midwives, requiring more detailed and/or personalised nutritional assessment and dietetic advice. Whilst the Healthy Start vitamins may be appropriate for many pregnant women, they may be insufficient for others who are at risk of nutritional deficiencies, including vitamin A.

Nutritional assessment and counselling should be made available to nutritionally vulnerable groups and a multidisciplinary approach where midwives can refer or signpost women to appropriately qualified dietitian's or nutritionists is needed. A paper by Barger (2010) outlining the effects of inadequate maternal nutrition on perinatal outcomes also advocates nutritional counselling and suggests women complete a form of dietary recall prior to antenatal appointments, screening for vulnerable populations, who can then be referred appropriately.

This review highlights micronutrient and supplement intakes during pregnancy, energy and macronutrient intakes are beyond the scope of this paper. This is covered in a paper by Blumfield et al (2012) entitled 'Systematic review and meta-analysis of energy and macronutrient intakes during pregnancy in developed countries'.

N.B. It should be noted that the information in this article applies to nutritional deficiencies as a result of inadequate dietary intakes and not due to genetic or metabolic disorders.

References

Abayomi, J. C., Watkinson, H., Boothby, J., Topping, J. and Hackett, A. F. (2009) Identification of 'hot spots' of obesity and being underweight in early pregnancy in Liverpool. *Journal of human nutrition and dietetics : the official journal of the British Dietetic Association, 22*(3), pp. 246-54.

Allgrove, J. and Mughal, M. Z. (2014) Calcium deficiency rickets: extending the spectrum of 'nutritional' rickets. *Archives Of Disease In Childhood, 99*(9), pp. 794-795.

Bainbridge, J. (2007) The trouble with size 0. *British Journal of Midwifery, 15*(1), pp. 38-38 1p.

Barger, M. K. (2010) Maternal Nutrition and Perinatal Outcomes. *Journal of Midwifery & Women's Health, 55*(6), pp. 502-511 10p.

Barker, D. J. P., Gelow, J., Thornburg, K., Osmond, C., Kajantie, E. and Eriksson, J. G. (2010) The early origins of chronic heart failure: impaired placental growth and initiation of insulin resistance in childhood. *European Journal of Heart Failure, 12*(8), pp. 819-825.

Bender, D. A. (2002) The Vitamins. in Gibney, M. J., Vorster, H. H. and Kok, F. J., (eds.) *Introduction to Human Nutrition*,UK: Blackwell

Berti, C., Biesalski, H. K., Gärtner, R., Lapillonne, A., Pietrzik, K., Poston, L., Redman, C., Koletzko, B. and Cetin, I. (2011) Micronutrients in pregnancy: Current knowledge and unresolved questions. *Clinical Nutrition, 30*(6), pp. 689-701.

DH (2008) Getting maternity services right for pregnant teenagers and young fathers. in Department for Health and Department for children, s. a. f., (eds.),Nottingham: DCSF publications.

Doak, C. M., Adair, L. S., Bentley, M., Monteiro, C. and Popkin, B. M. (2004) The dual burden household and the nutrition transition paradox. *International Journal of Obesity, 29*(1), pp. 129-136.

Fowles, E. R. (2002) Comparing pregnant women's nutritional knowledge to their actual dietary intake. *MCN. The American Journal Of Maternal Child Nursing, 27*(3), pp. 171-177.

Gluckman, P. D., Cutfield, W., Hofman, P. and Hanson, M. A. (2005) The fetal, neonatal, and infant environments-the long-term consequences for disease risk. *Early Human Development, 81*(1), pp. 51-9.

Haider, B. A. and Bhutta, Z. A. (2012) Multiple-micronutrient supplementation for women during pregnancy. *The Cochrane Database Of Systematic Reviews, 11*, pp. CD004905.

Han, Z., Mulla, S., Beyene, J., Liao, G. and McDonald, S. D. (2011) Maternal underweight and the risk of preterm birth and low birth weight: a systematic review and meta-analyses. *International Journal of Epidemiology, 40*(1), pp. 65-101.

Harris, A. A. and Barger, M. K. (2010) Specialized care for women pregnant after bariatric surgery. *Journal of Midwifery & Women's Health, 55*(6), pp. 529-539.

Jackson, A. A. and Robinson, S. M. (2001) Dietary guidelines for pregnancy: a review of current evidence. *Public Health Nutrition, 4*(2B), pp. 625-630.

Jeric, M., Roje, D., Medic, N., Strinic, T., Mestrovic, Z. and Vulic, M. (2013) Maternal pre-pregnancy underweight and fetal growth in relation to institute of medicine recommendations for gestational weight gain. *Early Human Development, 89*(5), pp. 277-281 5p.

Judd, J. (2013) Rickets in the 21st century: A review of the consequences of low vitamin D and its management. *International Journal of Orthopaedic & Trauma Nursing, 17*(4), pp. 199.

Keen, C. L., Clegg, M. S., Hanna, L. A., Lanoue, L., Rogers, J. M., Daston, G. P., Oteiza, P. and Uriu-Adams, J. Y. (2003) The plausibility of micronutrient deficiencies being a significant contributing factor to the occurrence of pregnancy complications. *JOURNAL OF NUTRITION, 133*(5), pp. 1597S-1605S.

Lopez, S. A. R., Poon, A. N., Szeto, I. M. Y., Ma, D. W. L. and Anderson, G. H. (2013) High multivitamin intakes during pregnancy and postweaning obesogenic diets interact to affect the relationship between expression of PPAR genes and glucose regulation in the offspring. *JOURNAL OF NUTRITIONAL BIOCHEMISTRY, 24*(5), pp. 877-881.

McMahon, D. M., Liu, J., Zhang, H., Torres, M. E. and Best, R. G. (2013) Maternal obesity, folate intake, and neural tube defects in offspring. *Birth Defects Research Part A - Clinical and Molecular Teratology, 97*(2), pp. 115-122.

NICE (2008a) Maternal and Child Nutrition. in *NICE Public Health Guidance 11*: National Institute for Health and Clinical Excellence.

NICE (2008b) *Maternal and child nutrition*: National Institute for Health and Care Excellence.

NICE (2010) Weight management before, during and after pregnancy. in *NICE Clinical Guideline 27*: National Institute for Health and Clinical Excellence.

Nyaradi, A., Li, J. H., Hickling, S., Foster, J. and Oddy, W. H. (2013) The role of nutrition in children's neurocognitive development, from pregnancy through childhood. *FRONTIERS IN HUMAN NEUROSCIENCE, 7*.

Osmond, C. and Barker, D. J. (2000) Fetal, infant, and childhood growth are predictors of coronary heart disease, diabetes, and hypertension in adult men and women. *Environmental Health Perspectives, 108 Suppl 3*, pp. 545-53.

Polanska, K., Muszynski, P., Sobala, W., Dziewirska, E., Merecz-Kot, D., Hanke, W., Polańska, K. and Muszyński, P. (2015) Maternal lifestyle during pregnancy and child psychomotor development - Polish Mother and Child Cohort study. *Early Human Development, 91*(5), pp. 317-325 9p.

SACN (2006) *SACN folate and disease prevention report*. London: Scientific Advisory Committee on Nutrition

Salihu, H. M., Lynch, O., Alio, A. P., Mbah, A. K., Kornosky, J. L. and Marty, P. J. (2009) Extreme maternal underweight and feto-infant morbidity outcomes: a population-based study. *Journal of Maternal-Fetal & Neonatal Medicine, 22*(5), pp. 428-434 7p.

Shah, P. S. and Ohlsson, A. (2009) Effects of prenatal multimicronutrient supplementation on pregnancy outcomes: a meta-analysis. *CMAJ: Canadian Medical Association Journal = Journal De L'association Medicale Canadienne, 180*(12), pp. E99-E108.

Strain, J. J. and Cashman, K. D. (2002) Minerals and Trace Elements. in Gibmey, M. J., Vorster, H. H. and Kok, F. J., (eds.) *Introduction to Human Nutrition*,UK: Blackwell.

Treffers, P. E., Olukoya, A. A., Ferguson, B. J. and Liljestrand, J. (2001) Care for adolescent pregnancy and childbirth. *International Journal for Gynaecology and Obstetrics, 75*, pp. 111-121.

Williamson, C. S. (2006) Nutrition in pregnancy. *British Nutrition Foundation Nutrition Bulletin, 31*, pp. 28-59.

Yetley, E. A. (2007) Multivitamin and multimineral dietary supplements: definitions, characterization, bioavailability, and drug interactions. *American Journal of Clinical Nutrition, 85*(1), pp. 269S-276S.

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